K2000 Digital Temperature Controller

Installation & Operators Guide

Rev E - July 2014

CE

This document outlines the installation and setup of the MMR K2000 Digital Temperature Controller.

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Specifications

The K2000 Temperature controller is built on and intended to replace the proven K20 Temperature Controller previously offered by MMR Technologies. This temperature controller through self tuning PID offers stable temperature measurement and control to 0.05K *(Result may vary with load and vacuum).* Manual temperature control and monitoring is also possible through the built in User Interface. These devices are intended for use with MMR Refrigerators only.

Voltage:	115VAC 60Hz / 220VAC 50Hz *(Not user selectable, Refer to label at rear of unit)*
Power Consumption:	60W
Temperature Inputs:	2
Sensor Type:	PT100 RTD F Series *(4-wire Kelvin connection)*
Resolution:	±0.0.5K
PID Control:	Yes *(1 Channel)*
Heater Power:	0 - 10W
Temperature Range:	60K - 1000K
Communications:	RS232 or USB1.0 *(See communications protocol)*
Weight:	10Lbs
Dimensions:	8.5"(W) x 3.5"(H) x 14.25"(D)
Environmental:	Indoor use only, 5C - 40C Temperature, 2000M Max Altitude, 80% Humidity for temperatures up to 31 °C decreasing linearly to 50 % Rel humidity at 40 °C.

System Requirements

For computer control the K2000 Temperature controller is designed for use with 'MMR Technologies Suite' which must be installed prior to using this device. For custom control of this device see page 24, please note MMR may not support custom configurations and in some cases the warranty may be void.

Operating System:	Windows 2000, Windows XP, Windows 7, Windows 8
Hardware:	32BIT / 64BIT INTEL or AMD Processor
Memory RAM:	2GB
Memory Hard Disk:	1GB
Peripheral Interface:	1x RS232 Serial or USB1.0.
Mac OS, Linux:	Not Supported

Environmental and Safety

The K2000 Digital Temperature controller is built on and intended to replace the proven K20 Temperature Controller previously offered by MMR Technologies. Please observe the following safety warnings. Do not open the enclosure, do not operate on any voltage other than specified, do not attempt to service or modify the equipment, do not operate in wet/damp locations. Warning, electrical shock, injury or death may occur if the device is opened or the earth modified. Use only the cables supplied with the device and ensure a proper Ground is present. The SB1000 should only be used as intended and should not be used for any other purpose. Any non-intended use could cause fire, loss of life, loss of equipment, and bodily harm. User assumes all risk should the equipment be misused, modified, or use in an unintended manner. Contact MMR for service

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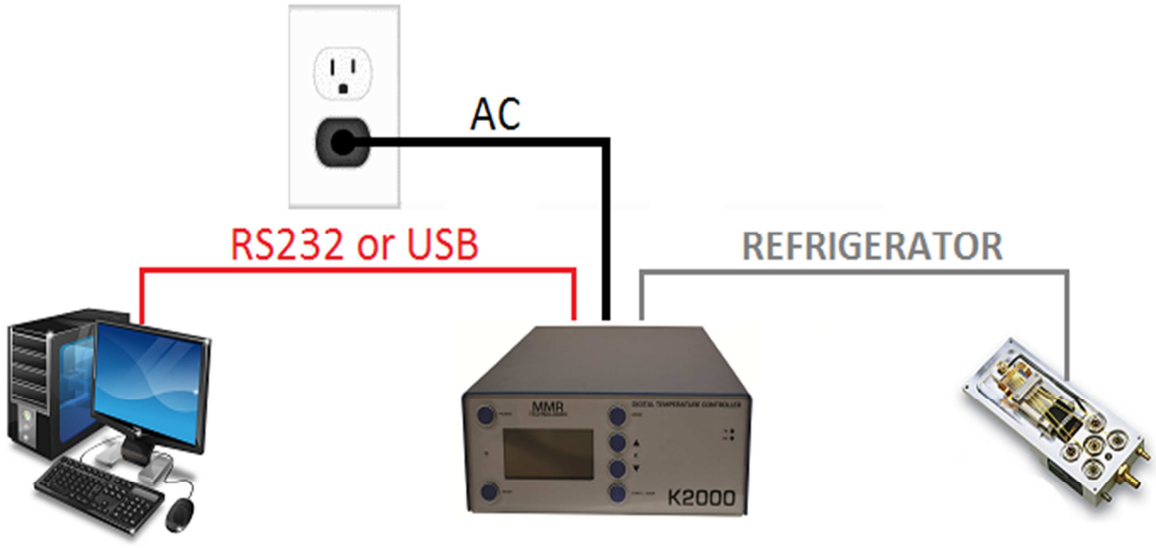
Installation

Before proceeding please ensure the MMR Technologies Software Suite is installed and the following items are present:

- 1x K2000 Temperature Controller *(Correct Voltage)*
- 1x AC Power Cable
- 1x RS232 DB9 Serial Cable
- 1x USB 3FT Cable
- 1x User Manual and Software / Driver Installation CD
- 1x 4FT Refrigerator Ribbon Cable
- 1x MMR 4-Wire Kelvin Connection Breakout Board

Please connect the K2000 Temperature Controller as shown below. Do not connect both the RS232 Serial cable and USB cable together, these are provided as two options should you be short of spare PC ports.



Once connected and with the PC running you may now power-up the K2000 Temperature Controller. Please first insure the AC Power switch at the rear of the unit is 'ON' *(see figure 6 for further information).* Press the front button labeled power to power up the unit. If the USB cable was used Windows will automatically assign a comport. This must be identified, and if necessary changed to be in the range of 1-16. *(See page 5 or contact your system administrator)* Please note down the assigned Comm port Number as this will be required to communicate with the device.

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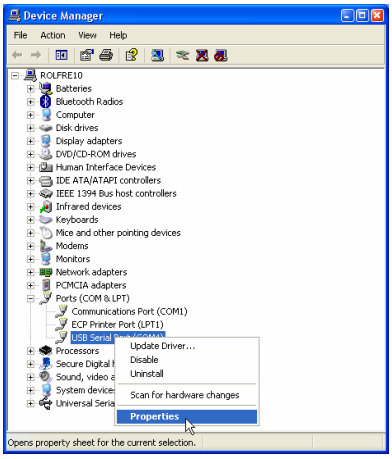
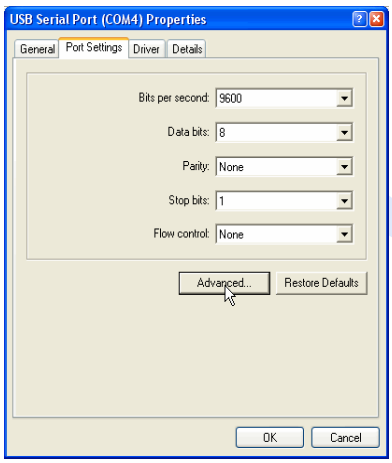
Changing Port Numbers in Windows

(Note: Administrator access maybe needed, contact your IT department)



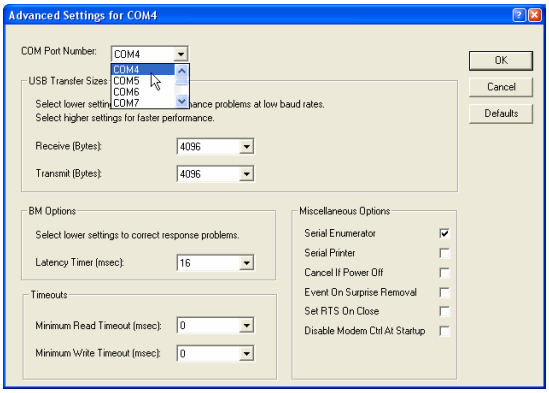
1/. Open Device Manager.
(Control Panel -> Device Manager)

2/. Select the corresponding Serial Converter Device.
(Right Click -> Left Click Properties)



3/. Click on the 'Port Settings' Tab.

4/. Click Advanced.



5/. Select a Comm port between 1 - 16 that is not in-use by other hardware. Click OK.
(Note: On some computers you may need to disconnect (unplug) and reconnect the device to make the changes permanent.)

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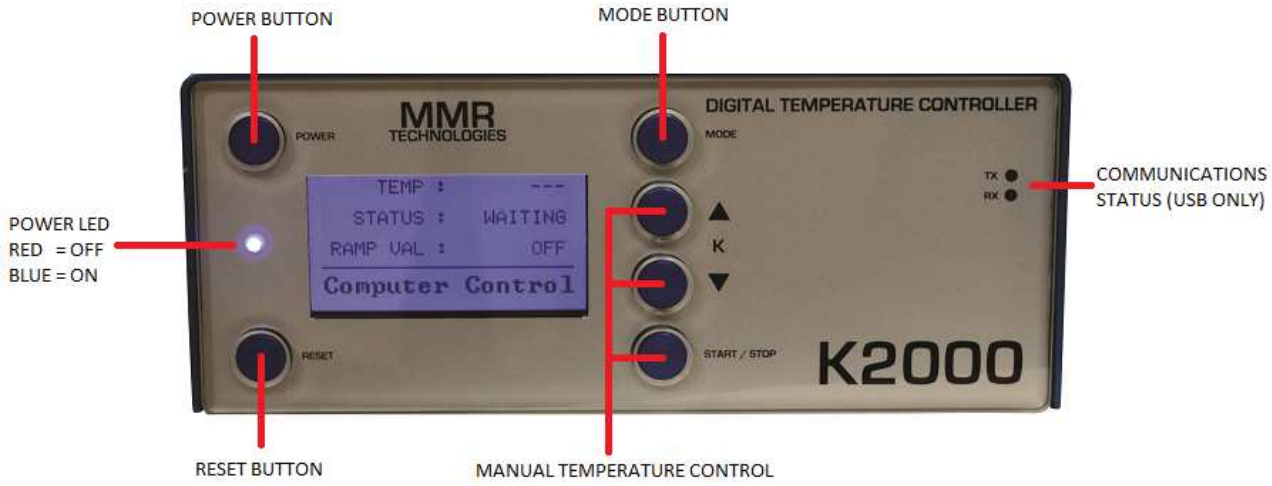
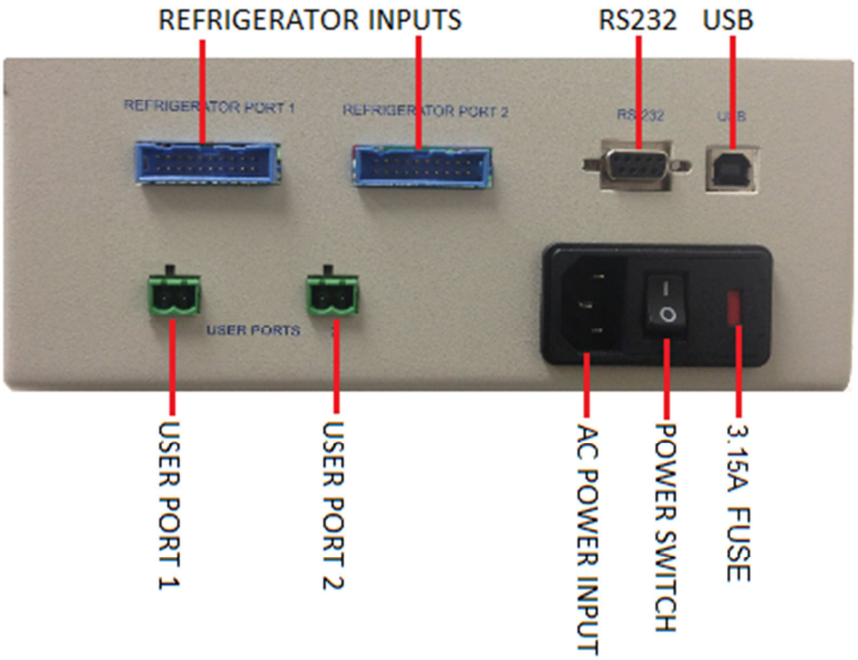
Front / Rear Panel Interface



Note: The Power button must be held for 3 seconds to power down the unit.



*Replace fuse with 3.15A Slow Blow (IEC 127-2 or similar) ONLY.

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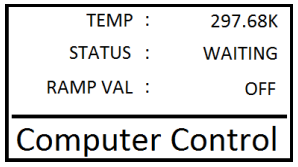
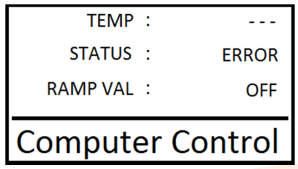
Getting Started

Before Starting the MMR Technologies Suite software it will be necessary to familiarize yourself with the Built In User Interface, there are several modes which are outlined below. These can be navigated by using the "Mode" button.

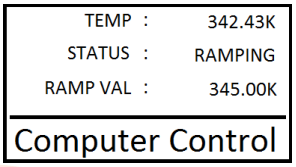
Mode 1: COMPUTER CONTROL ***(This mode must be selected for Communicating with the software)***



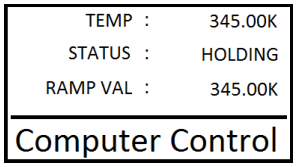
Ready State



No Refrigerator Present

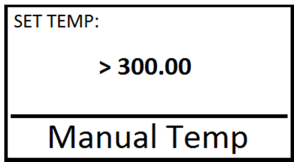


Ramping to 345.00K

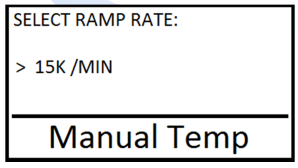


Holding at 345.00K

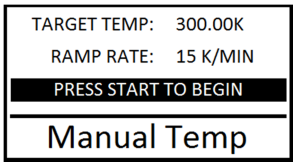
Mode 2: MANUAL CONTROL ***(This mode is for standalone Temperature Control, No PC)***



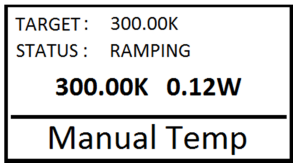
Select a Temperature and Press Start/Stop



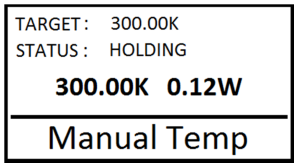
Select a Ramp Rate and Press Start/Stop



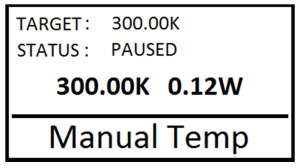
Press Start/Stop to Begin



Ramp in Progress



Ramp Target Reached



Press' Start / Stop' to Pause and Resume. Press 'Mode' to Exit.

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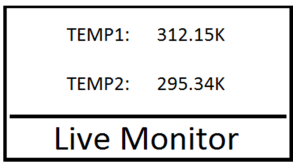
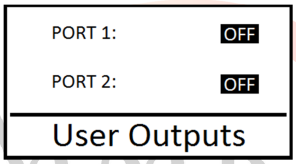
Getting Started

Mode 3: LIVE MONITOR ***(This mode simultaneously displays the Temperature from BOTH Refrigerator Inputs)***



The controller will automatically switch to this mode when the PC Software is plotting both Temperatures.
No further computer control is possible in this mode.

Mode 4: USER OUTPUTS ***(This mode is for the manual toggling of the Dry Relay contacts at the rear of the unit)***
(See page 16, for information on the Rear User Ports.



Pressing the adjacent 'Arrow Keys' will toggle the Outputs, the selected state of the Outputs will be restored each time the controller is powered up.
These Dry Contact Outputs are electrically Isolated from the Unit (including grounding). The user can pass any signal through these relay outputs for external control of temperature related hardware or ALARM circuitry. Autonomous control of these Ports is possible through the MMR Software Suite.

Approvals
UL E29244, CSA LR81479

Contact ratings
500mA, 20VDC
Mechanical endurance 100x106 operations

Contact Data
Rated voltage :20VDC, 500mA
Max. switching voltage : 100VDC
Rated current : 500mA, 20VDC
Limiting making current 500mA
Limiting breaking current 500mA
Contact material: Ruthenium
Initial contact resistance 200mΩ max. at 10mA, 6VDC
Operate/release time max., incl. bounce: 1.5/0.5ms

Insulation Data
Initial dielectric strength between open contacts: 250VDC, between contact and coil: 500VDC
Initial insulation resistance between insulated elements: 1010Ω at 100VDC
Capacitance between open contacts typ. 0.5pF

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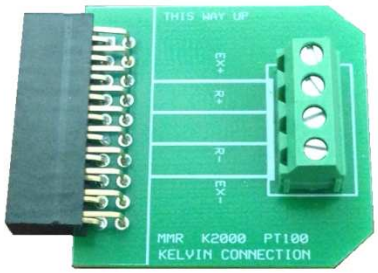
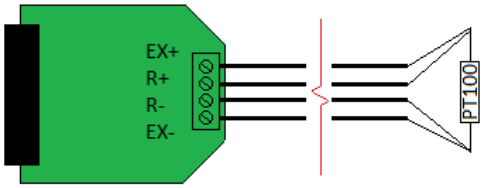
Using the 4-Wire Kelvin Board



The purpose of this board is to allow easy user integration of an additional sensor (TYPE PT100 RTD - F Series) to the system for auxiliary temperature monitoring purposes. Although this card can interface to either refrigerator port it is generally intended for use on Refrigerator Port #2. One unique feature of the K2000 is that refrigerators can be hot swapped while the device is powered ON. *See below for wiring information.*



The advantage of using a 4-wire Kelvin connection is the conductors (cable) used can by of varying length and immune to various forms of interference. PT100 (100ohm Platinum Resistors) are readily available from suppliers such as OMEGA (Part# F2020-100-B-100), and also from MMR Technologies (Part# 3192369-003).

Resistance vs. Temperature Values per IEC60751

Temp (°C)	Resistance (Ω)	Temp (°C)	Resistance (Ω)	Temp (°C)	Resistance (Ω)
-200	18.52	150	157.33	450	264.18
-150	39.72	200	175.86	500	280.98
-50	80.31	250	194.10	550	297.49
0	100.00	300	212.05	600	313.71
50	119.40	350	229.72	650	329.64
100	138.50	400	247.09	700	345.28

The Datasheet for the recommended sensor is http://www.omega.com/pptst/F1500_F2000_F4000.html

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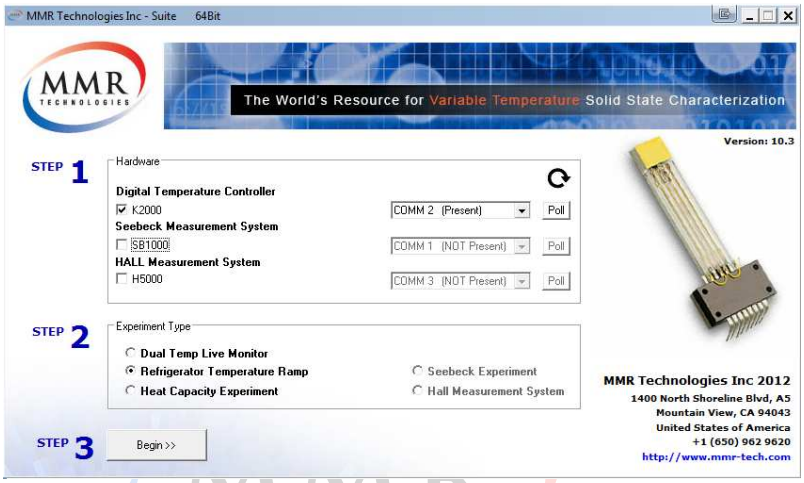
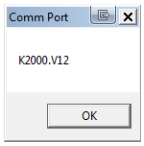
Setting a Temperature

With the Hardware now installed and an MMR Refrigerator properly attached *(see documentation supplied with Refrigerator)* it is now time to start the MMR Software Suite.

Locate and run the 'MMR Technologies Suite' icon on the Desktop or Start Menu.



Step 1 - Device ports are easily verified through the welcome screen above, select the port number the K2000 Temperature Controller is connected to *(shown as present next to the K2000)* and press 'Poll'. If the K2000 is connected to that port, powered on and set to 'Computer Control' it will respond with a Device name and Version number.



If the port number is not visible try refreshing the port list by clicking the refresh icon above the "Poll'' buttons. If this does not resolve the issue try restarting the computer. For further assistance contact your system administrator and finally the MMR Helpdesk (See contact information on Page 27)

Step 2- Select 'Refrigerator Temperature Ramp' This will select the 'Temperature & Power vs Time' plot. This experiment allows the user to set any given temperature in the range of 70K - 700K depending on attached refrigerator and Gas system. Please see the manual that accompanied your refrigerator for Low and High temperature limits. Refrigerators can be easily destroyed if these limits aren't adhered to.

Step3 - Press 'Begin'

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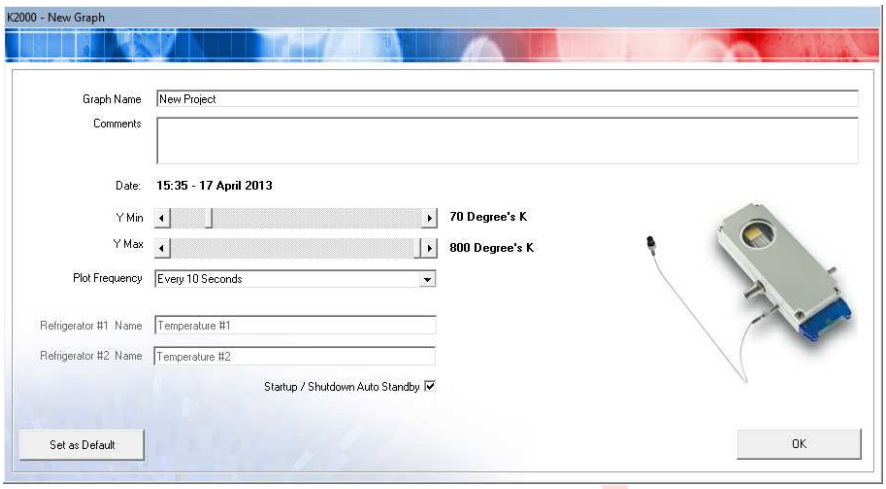
Setting a Temperature

Before proceeding, Graphing and Plotting parameters can be modified.



Graph Name, Comments;
An Experiment name and further comments can be also be added to the project. These will be included when printing a Plot later.

Y-Min / Y-Max
These parameters can be manually set, however through a built in easy-to-use Zoom function it may not be required. These settings cannot be modified in 'Dual Temp Live Monitor' mode.

Plot Frequency
This option is used for extended recording times >24 Hrs. The Graphing software is capable of processing 2Million points. And will record continuously once started, however points will be lost from the beginning of the plot when the recorded points reach 2 Million. (Ever point over 2 million recorded, 1 point will be deleted from the beginning of the recording.?)

Startup / Shutdown Auto Standby
This option is recommended at all times when cooling. Should the temperature control be terminated at any point in the experiment the Set Point *(K2000 Temperature Setting)* will automatically be set at 300K *(Or Room Temperature)* This will prevent run away heating/cooling leading to refrigerator damage.

Press 'OK' to Start.

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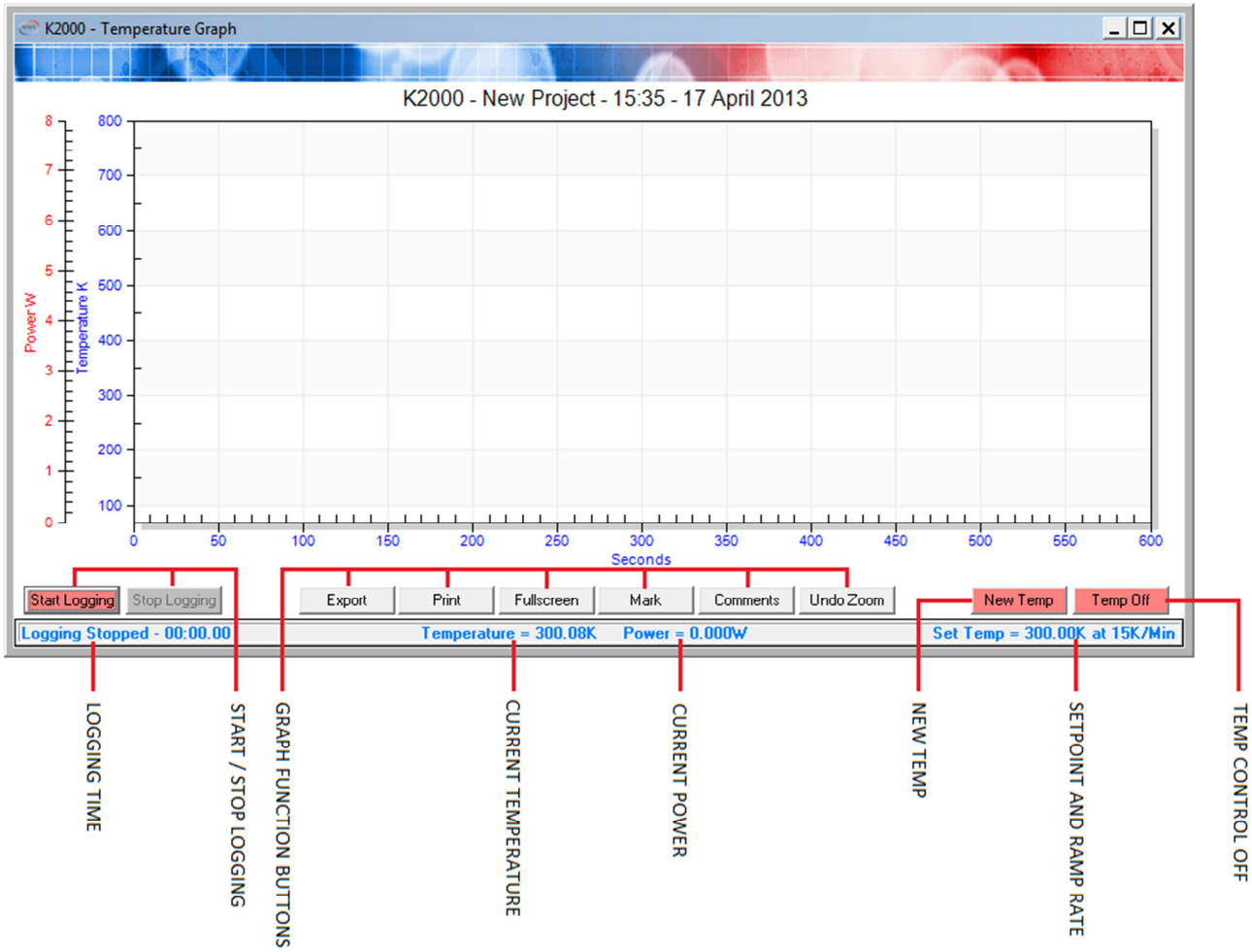
Setting a Temperature



The above illustration outlines the buttons and their associated functions of the Temperature Graph, to begin logging select 'Start Logging', the current Set Point is already set at 300K as previously the 'Startup / Shutdown Auto Standby' option was selected.

The Front LCD display or User Interface of the K2000 Temperature controller should also show 300.00K as the Setpoint, this indicated the device is communicating correctly with the software.

To proceed to a specific temperature select "New Temp". *Note: At any time during an experiment clicking "Temp Off" will disable the K2000 Temperature Control and allow the Refrigerator to freely cool or warm to 300K.*

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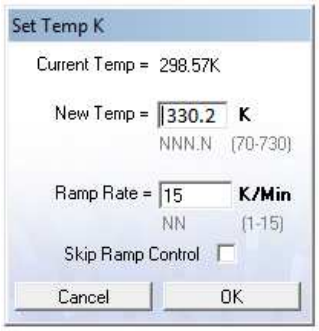
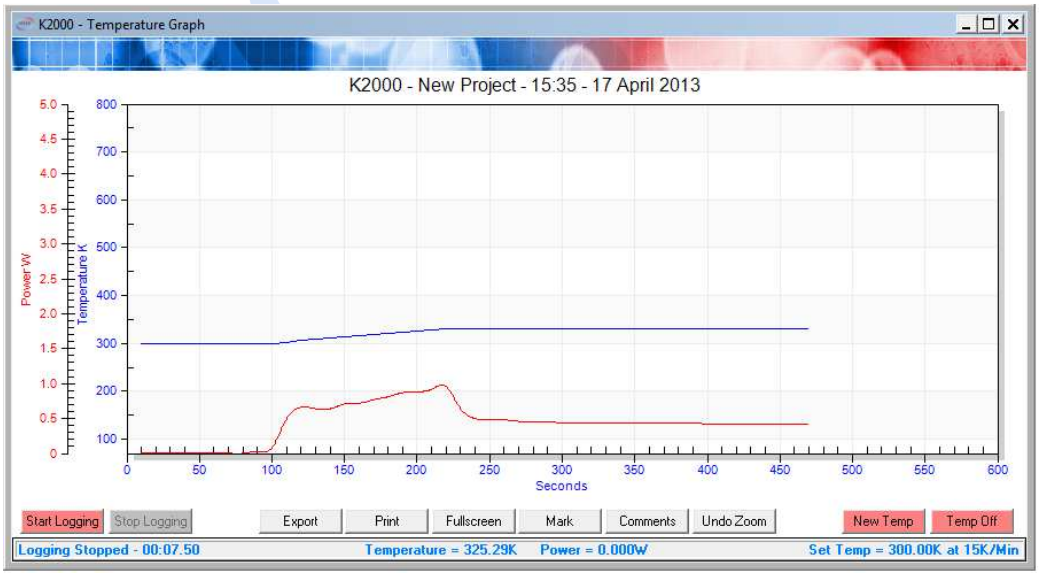
Setting a Temperature



The above window allows the user to input a given temperature to one decimal place. *(e.g 310.1)* If no decimal place is necessary simply enter 310. A ramp rate between 1K / Min and 15 / Min is also essential to ensure no damage to the refrigerator is done. This ramp rate is applicable to heating and cooling ramps. *(positive or negative slope).*

In some rare situations it may be necessary to skip the Ramp Control in which case the option "Skip Ramp Control" can be selected. It is worth noting that this is **dangerous** and can potentially destroy the refrigerator.



The X Axis Scale (Time) automatically increments as the plot proceeds, the Power Scale can be selected from the master 'K2000' menu shown on page 14.

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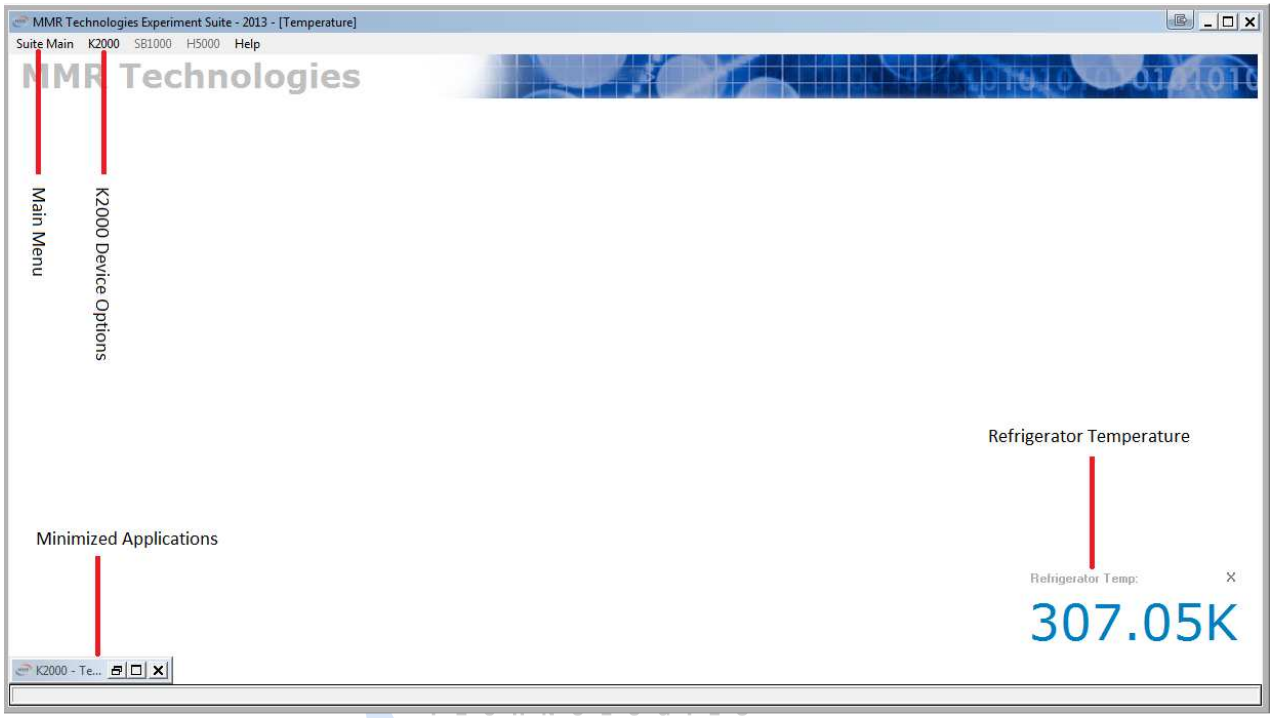
Main Interface



The main interface of the MMR Technologies Suite is shown above, this is the primary container for all MMR applications. The Applicable items for the K2000 Temperature Controller are show above. Double Clicking of the Refrigerator Temperature *(bottom right)* will display customization options which include "Color" and "Temperature Unit". This is further explained in the Software Installation Guide.

K2000 Spooler

[Main Suite -> K2000 - > Show Spooler]

This window shows the communications queue and response from the associated device, in this case the K2000 Temperature Controller. Troubleshooting is the primary use for this window. However clicking "Send" is a short cut to the' Main Communications Console' outlined in the software Installation Guide.

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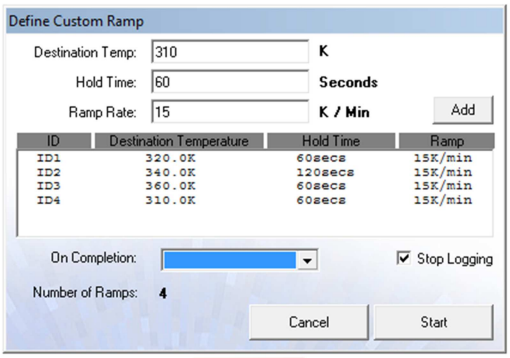
Custom Ramp Programming

[Main Suite -> K2000 -> Custom Ramp]

This is a feature unique to the K2000 Temperature Controller in which multiple temperatures and ramp rates can be preset and allowed to run autonomously.



Destination Temp: The required set point. *(Temperature Setting, Set Point)*

Hold Time: Otherwise known as 'Wait' or 'Soak Time' this is the amount of time in seconds the controller waits once the destination temp has been reached before proceeding to the next temperature setting.

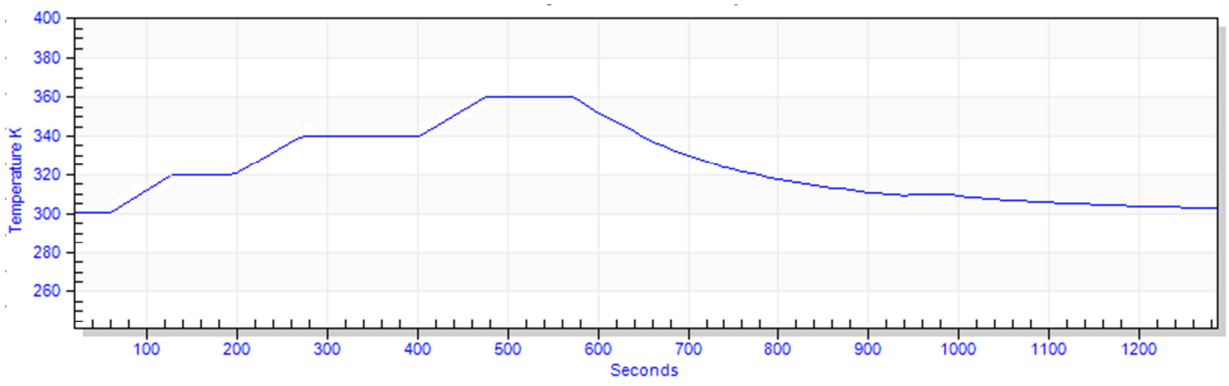
Ramp Rate: The Slope of the Heating or Cooling.

On Completion: Options 'Control Off' or 'Hold'.

Control Off disables the temperature control. It is worth ensuring the Auto Standby option is selected *(see page 11)* if cooling is active.

Hold holds the refrigerator at the last temperature. If you are unsure if 'Auto Standby' is selected it is worth adding 300K and Hold as the last step in the ramp.

Stop Logging: Terminates the plot after the Ramp completion.



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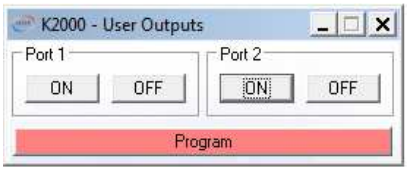
User Port Programming

[Main Suite -> K2000 -> User Outputs]

The built in Dry Contact Relays inside the K2000 Temperature Controller *(see page 8)* can be easily controlled either manually or automatically.

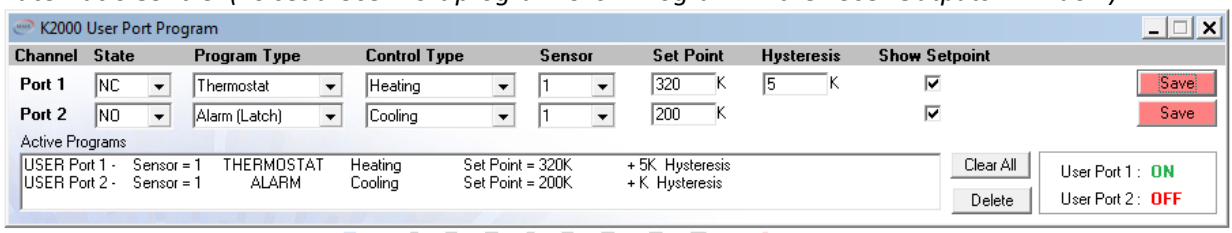
Manual Control



Toggling of the Ports is achieved using the 'User Output'' Control shown to the left.

Note: The K2000 must be set to 'Computer Control'

Automatic Control *(To set a User Port program Click 'Program' in the "User Outputs" Window)*



The above application allows up to two separate programs to be run simultaneously. There are two program types (Thermostat and Alarm).

PORT - The user output the program will control (1 or 2)

STATE - Relay State Below the Setpoint if **Heating** and Above the Setpoint if **Cooling**

PROGRAM TYPE - Thermostat *(Real Time Temperature Control)*, Alarm Latch *(A state change if the Setpoint is breached, this requires user acknowledgement should it occur.)*

CONTROL TYPE - This tells the controller if the Experiment Control is Heating or Cooling. *(See Page 17)*

SENSOR - Which Refrigerator Temperature to Monitor (1 or 2)

SETPOINT - The Control Temperature

HYSTERESIS - The temperature control Gap between the state change and Setpoint. The larger the hysteresis setting the less state changes occur when the temperature is close / equal to the Setpoint.

State Change *(Heating) = Setpoint - Hysteresis*

State Change *(Cooling) = Setpoint + Hysteresis*

SHOW SETPOINT - Shows the Setpoint setting on the Temperature Plot.

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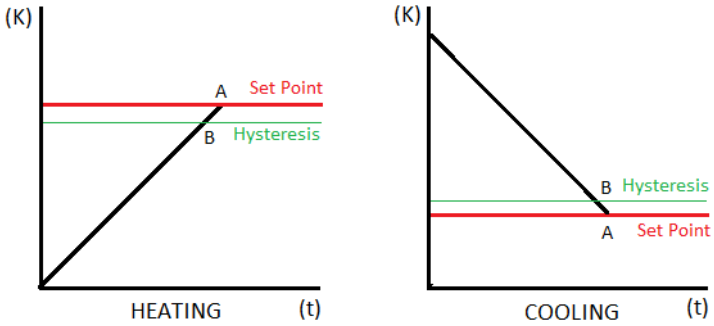
User Port Programming

HYSTERESIS and EXPERIMENT TYPE



The illustration to the left outlines the behavior of the Experiment Type vs Hysteresis,

A = Relay state changed.

B = Relay restored to original state.

(note when the 'Program Type' is 'Alarm' there is no hysteresis setting as the Alarm latches at one point only)

ALARM

The Alarm message will appear when the Setpoint condition is reached or exceeded, after acknowledging the message after 5 seconds it will re-appear unless the Alarm condition is resolved or the program is cancelled.

PROGRAM RUNNING

When a program is set the above message is displayed below the temperature in the Main Software Suite.

NOTES

The software updates the user port status to the controller every 5 seconds. This means that some precision control may be difficult because of this delay.

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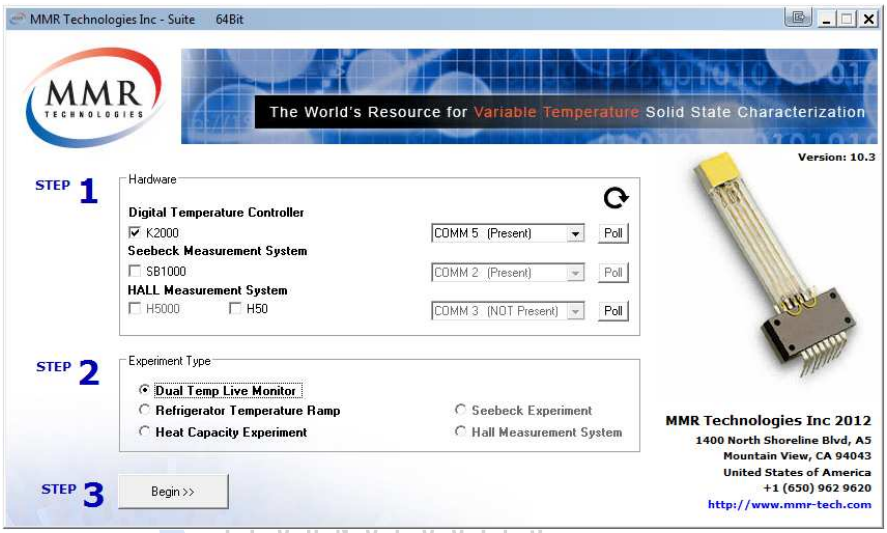
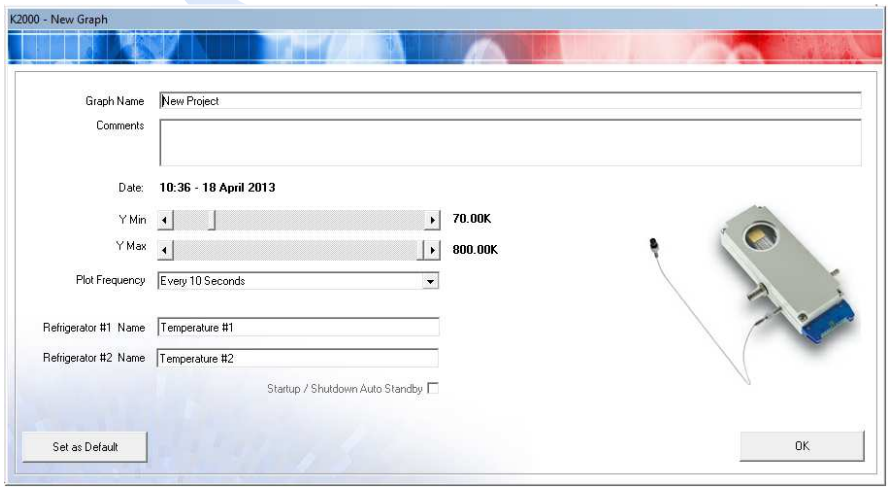
Dual Temp Live Monitor

[Main Suite -> Suite Main -> New Project] or [Close Entire Application and Restart]

This Project allows both temperatures to be plotted Simultaneously , NO temperature control is available in this mode as it is strictly intended for monitoring purposes only. When selecting this project the software instructs the K2000 Temperature Controller to switch to 'Live Monitor' Mode.





When starting a new "Dual Temp Live Monitor" project it is possible to name the individual Temperature inputs. The (Y) Scale cannot be changed in this mode.

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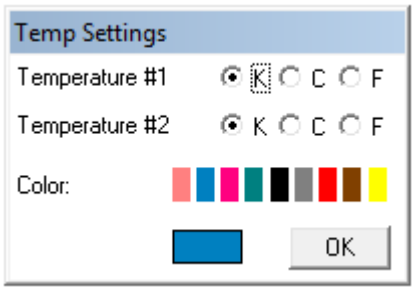
Dual Temp Live Monitor

Both Temperatures are displayed simultaneously along with their associated labels. To change color or Temperature Units double click the Temperatures. The following control will be shown.



To change the temperature unit for a given Temperature input, select amongst K,C or F. *Note the unit change does not affect the plot or stored data. This is for display purposes only.*

To select a color double click on the desired color selection and press OK to set.

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Graphing Functions

Double clicking the graph plot displays the Customization window, many options are available for customization the appearance of the graph and plot along with changing the plot type or hiding altogether. *(Fig 1)*

Additionally Right Clicking on the graph plot area shows a quick menu *(Fig 2)*

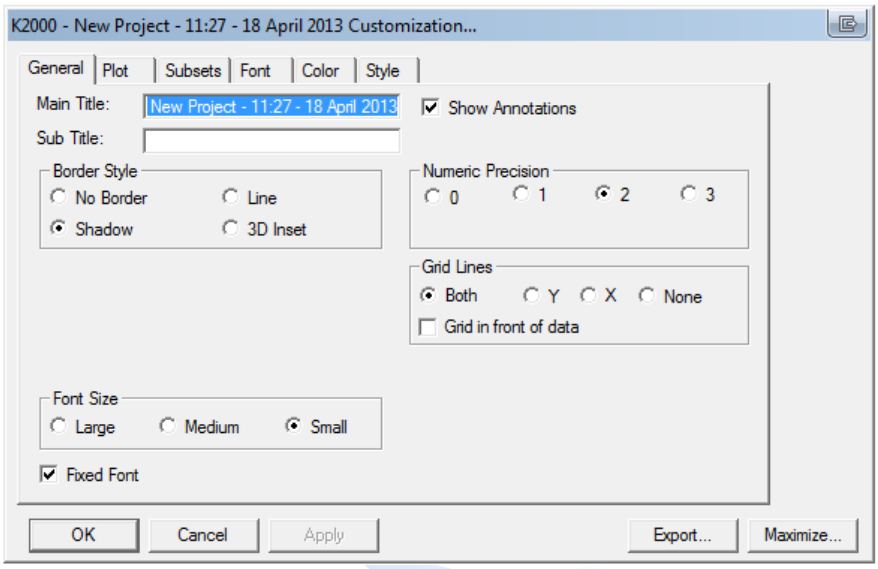
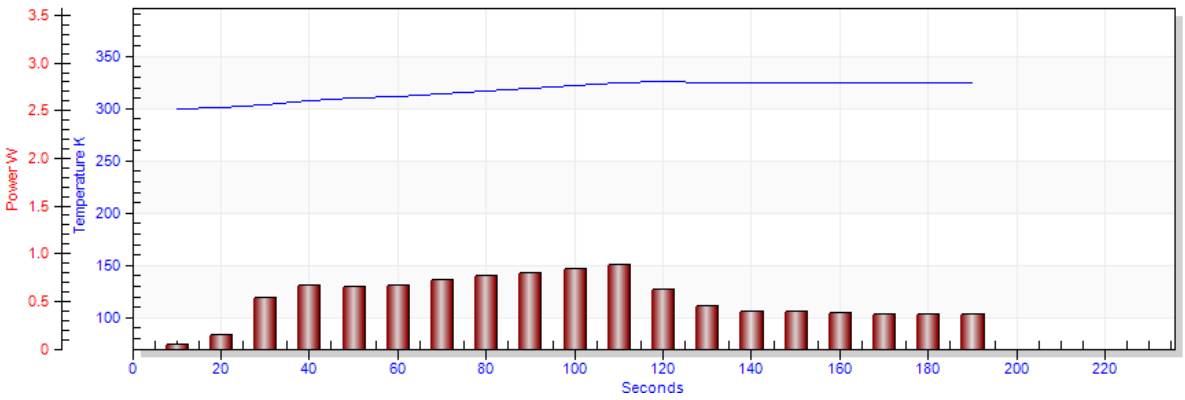


Figure 1. *Figure 2.*

Note: These settings are not permanent and will be reset each time a New Graph project is started



Example of changing the Power (W) Plot to a Bar Graph.

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Graphing Functions

The above buttons are associated with ever graph plot and have the following functions.

EXPORT - Opens the Export Window, this allows exporting the graph to the clipboard, to an image and raw data *(including .txt or .csv)*

PRINT - Prints the graph in image form. Axis Info, Title and Comments are included.

FULLSCREEN - Displays a snapshot of the graph in Full screen, press 'ESC' to close. *Note: The graph does not update in Full screen mode.*

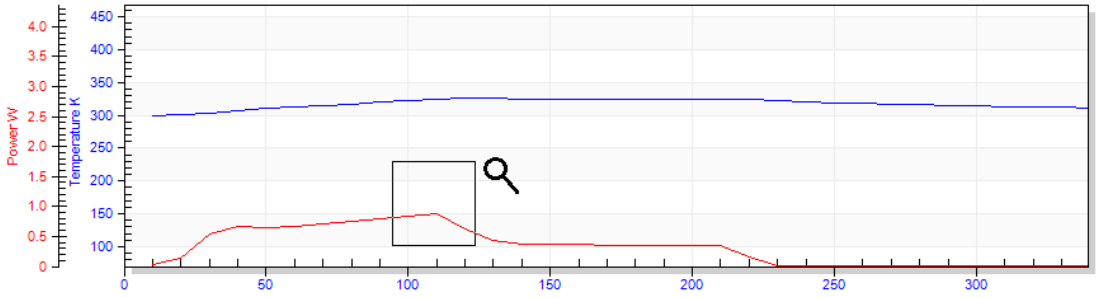
MARK - Add Annotations to graph, this allows the user to permanently add comments to a specific location on the graph plot. These comments are saved and included in printing.

COMMENTS - Modify Project Comments

UNDO ZOOM - Restores the graph to its original scale and view.

Zooming

To zoom click and drag a box to select a desired view. To undo zoom press 'z' or click "UNDO ZOOM"



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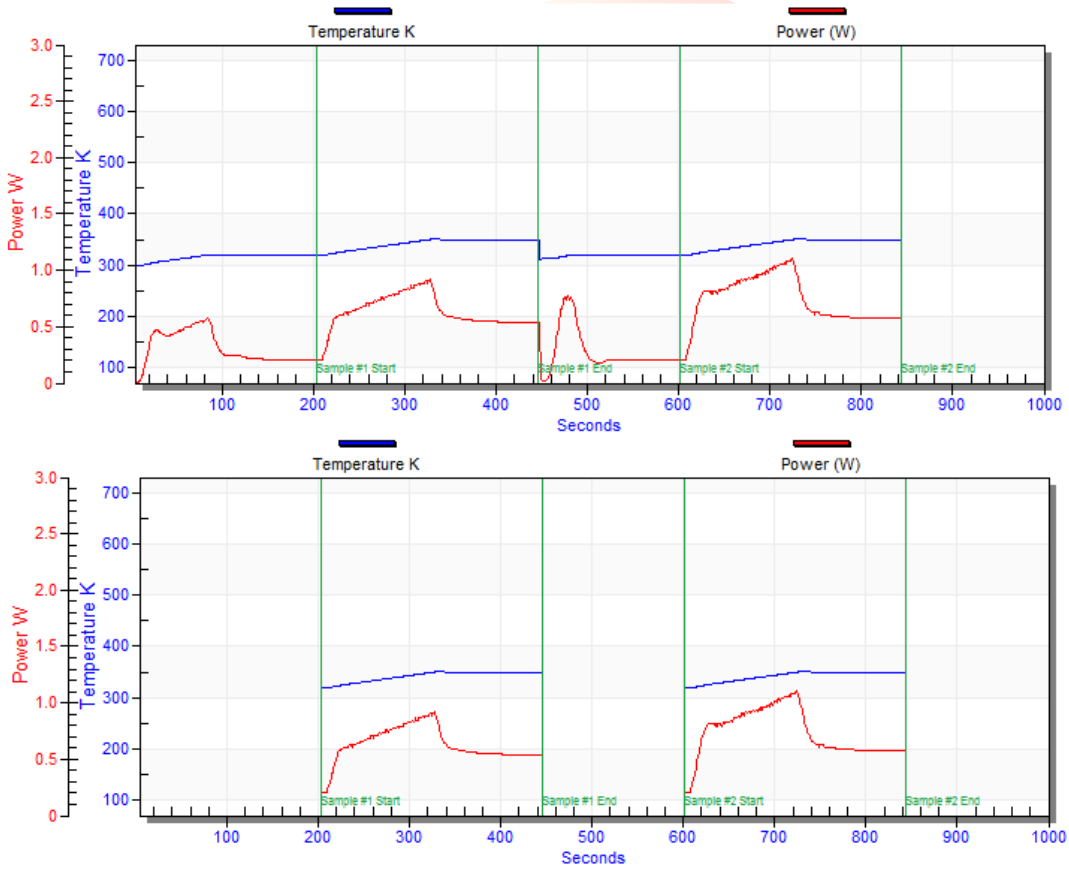
Heat Capacity Experiment

The Heat Capacity Experiment is a new feature offered by MMR Technologies and is unique to the K2000 Temperature Controller. The objective of this experiment is to measure thermal mass and/or detect phase transitions in a given sample. The experiment consists of measuring the precise power required to Heat an unloaded refrigerator from T_1 to T_2 and then repeating the process with a sample loaded on the refrigerator. The ΔP is then calculated for each measurement point and a Difference curve plotted. Similar Vacuums and proper mounting of the sample is required for accuracy.

Although the experiment is autonomous the user must specify 4 Main parameters.

Start Temperature - T_1 The Desired Start Temperature *(70 - 700K).*
Soak Time - The hold time, to allow for minimal thermal difference between sample and sensor.
Final Temperature - T_2 The final Temperature *(must be greater than the start Temperature).*
Ramp Rate - Desired Ramp Rate or Slope.



The upper plot shows the complete experiment data, the lower plot shows the unwanted data removed.

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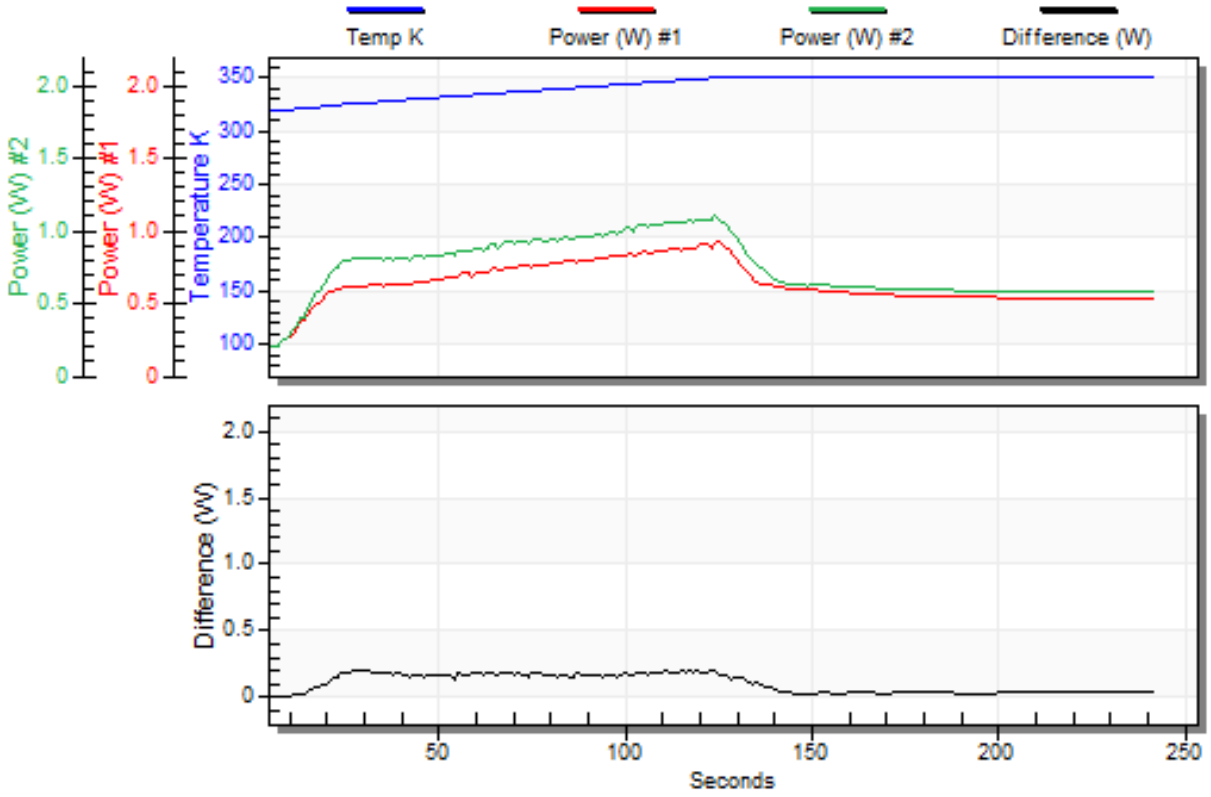
Heat Capacity Experiment Results



The above plots show the overlaid Power Curves from the Unloaded Run and the Loaded Run.
The Difference plot is the DELTA P of the two curves which is related to the thermal mass of the sample.

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Communications Protocol

Main Communications Type:	Serial
Communications Interfaces:	RS232, USB1.0
Serial Settings:	9600,N,8,1
Handshaking:	Hardware RTS/CTS
Echo:	Yes
Bus Pairing:	Parallel
Hardware CTS Timeout:	1000ms
Data Format:	ASCII / Plain Text

System Commands

Command	Format	Example	Description
"T"	TX	T1 = Temp 1 / T2 = Temp 2	Get Temp
"S"	SXXXX	S3005 = 300.5K / S775 = 77.5K	Set Temp
"U"	UXX	U11 = User Port 1 ON / U10 = User Port1 OFF	Set User Port
"C"	CXX	C1 to C10	Set PID Constant
"O"	O1		Power Down
"M"	M1		Get Constant
"N"	N1		Get Device Name
"R"	R1		Restart
"D"	D1		Live Monitor Mode

Note: Sending command S0 disables PID temperature control

Communications & Byte Order

Command Example: 'S3123' *(Set temp to 312.3K)*

1/. Set RTS High

2/. Wait for CTS

3/. Send 'S' as a Character *(VB Example on Next Page)*

4/. Send Temperature as a 2-Byte Word *(Highbyte First, Lowbyte Second)*

5/. Set RTS Low

Warning: Sending Temperature commands directly to the Controller bypass's the Ramp Control protection, permanent damage to the MMR Refrigerator is likely.

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Communications Protocol

Visual Basic Example - Sending a set temperature command

```
Private Sub Form_Load()
    MSComm1.CommPort = 2
    MSComm1.DTREnable = False
    MSComm1.Settings = "9600,N,8,1"
    MSComm1.RTSEnable = False
    MSComm1.OutBufferSize = 1024
    MSComm1.RThreshold = 1
    MSComm1.SThreshold = 0
    MSComm1.PortOpen = True
End Sub

Function SetTemperature()
  Dim command As Long
  Dim temp As Integer
  Dim counter As String

temp = 3123                                          'Set Temperature to 312.3K
        counter = 0
        MSComm1.RTSEnable = True                     'Set RTS High
        While MSComm1.CTSHolding <> True
          counter = counter + 1                      'Wait for CTS Signal
          If counter > 200000 Then
            MSComm1.RTSEnable = False                'Reset RTS
            MsgBox ("Time Out")
            Exit Function
          End If
        Wend
        MSComm1.OutBufferCount = 0
        MSComm1.InBufferCount = 0                    'Clear Buffers
        MSComm1.Output = Chr$(S) + Chr$(temp / 256) + Chr$(temp Mod 256) + Chr$(13)
        MSComm1.RTSEnable = False
End Function
```


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Troubleshooting

Symptom	Solution
Cannot Communicate with K2000	Ensure Unit is properly connected and powered on. Press Reset, Check that the device is connected to the correct Communications Port and the drivers are successfully loaded.
No Temperature is displayed	Please check Refrigerator Cables, Check that the temperature is displaying on the K2000 LCD User Interface Screen.
No Lights on K2000	Ensure Unit is plugged into an AC Power source, the rear power switch is on. Check Fuse.
Temperature Ramp is Unstable	Check refrigerator is under vacuum. Adjust PID Constant to 10.
Refrigerator doesn't Cool or Heat	Refer to Refrigerator Operators Manual, check for damage to refrigerator.
Temperature Accuracy has degraded	Return Refrigerator to MMR for Sensor service.
Software has an Error message	Contact MMR helpdesk

For all other errors or issues please contact the MMR Help Desk *(See Page 27)*

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Help Desk and MMR Contact Information

Help Desk Email Address:	support@mmr-tech.com
Bug Reporting:	spdbugs@mmr-tech.com
Technical Support Email Address:	matt@mmr-tech.com
Sales & Marketing Department:	sales@mmr-tech.com
Help Desk:	+1 650 962 9620
Office Hours:	7:30am - 5:00pm (Pacific Time) Monday - Friday
Physical Address:	1400 North Shoreline Blvd, Suite A5 Mountain View, California 94043 USA

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Declaration of Conformity

CE

Manufacturer: **MMR Technologies**
Model Name: **K2000**
Date: **July 2014**
Expires: **July 2018**

UL / IEC 61010

Application of Council Directives:

Low Voltage Directive (LVD) 2006/95/EC
Standards to which Conformity is Declared: IEC EN 61010-1 3rd Edition
Electrical equipment for measurement, control, and laboratory use
Pressure Equipment Directive (97/23/EC)
Conformity is declared to Annex I Essential Requirements of the Directive

Application of Council Directives:

Electromagnetic Compatibility Directive (EMC) 2004/108/EC
Conformity is declared to Annex I and II (EMC) 2004/108/EC

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